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EXTECH IV Athabasca uranium multi-disciplinary study of northern Saskatchewan and Alberta, Part 1: overview and impact[1]

C.W. Jefferson, G. Delaney, and R.A. Olson

Jefferson, C.W., Delaney, G., and Olson, R.A., 2003: EXTECH IV Athabasca uranium multidisciplinary study of northern Saskatchewan and Alberta, Part 1: overview and impact; Geological Survey of Canada, Current Research 2003-C18, 10 p.

Abstract: Fifteen subprojects have evolved within the EXTECH IV project, from data acquisition through interpretation to integration. These subprojects address two goals: 1) improvement of the Athabasca Basin geoscience framework by (a) mapping basement domains and their boundaries, relating uranium ore to reactivation structures and paleovalleys; (b) quantitative litho/sequence stratigraphy across drill camps and six regional deposystems; (c) refinement of alteration vectors to ore; (d) new SHRIMP (Sensitive High Resolution Ion Microprobe) standards for dating uraninite, and detrital U-Pb ages to constrain stratigraphy; (e) seismic imaging of stratigraphy, unconformity and P2 reverse fault zone; (f) paragenesis of organic matter; and (g) GIS databases; and 2) developing EXploration TECHnology (gamma-ray and multiparameter borehole geophysics, seismic reflection, gravity, and magnetotellurics) to calibrate ore, host-rock, and alteration parameters of the world-class McArthur River camp for deep exploration in the Athabasca Basin. Better decision-making, new staking, new ideas, and training of ten young scientists support northern sustainable development.

Résumé : Dans le cadre du projet EXTECH IV, 15 sous-projets sont passés successivement par les stades de l'acquisition, de l'interprétation et de l'intégration. Les objectifs visés par ces sous-projets étaient de deux ordres. Le premier visait l'amélioration du cadre géoscientifique du bassin d'Athabasca à l'aide des éléments suivants : a) cartographie des domaines du socle et de leurs limites, afin de relier la minéralisation uranifère à des structures de réactivation et à des paléovallées; b) cadre stratigraphique quantitatif, selon les approches lithologique et séquentielle, s'étendant aux camps de forage et à six systèmes de dépôt régionaux; c) meilleure définition des vecteurs d'altération pointant vers la minéralisation; d) nouveaux étalons pour la datation de la minéralisation à la microsonde SHRIMP (microsonde ionique à haute résolution et à haut niveau de sensibilité); e) imagerie sismique de la stratigraphie, de la discordance entre le socle et le Groupe d'Athabasca et de la zone de failles inverses P2; f) paragenèse de la matière organique; et g) bases de données de SIG. Le second objectif portait sur la mise au point de nouvelles TECHnologies d'EXploration (EXTECH) (gammamétrie et levés géophysiques multiparamétriques en sondage, sismique-réflexion, gravimétrie, magnétotellurique) pour l'étalonnage des paramètres de la minéralisation, des roches hôtes et de l'altération au camp minier de classe mondiale de McArthur River, afin de faciliter l'exploration en profondeur dans le bassin d'Athabasca. L'amélioration du processus de prise de décisions, les nouveaux jalonnements, les nouvelles idées et la formation de dix jeunes scientifiques ont tous eu une incidence sur le développement durable du Nord

[1] Contribution to the Targeted Geoscience Initiative (TGI) 2000–2003.

INTRODUCTION

Between 1971 and 1990, the contribution of nuclear energy to world electrical power rose from 2 to 17%, where it has remained. In the leading industrial countries, notably European Union countries, the United States and Japan, nuclear energy accounts for 20 to 30% of total electrical requirements. Primary worldwide uranium production in 1997 was 35 692 t U, with Canadian production representing approximately 34% of this total. During the same period, Canadian uranium sales were 11 274 t U (29.3 M lbs U_3O_8), reportedly valued at US$402.25 million (Thomas et al., 2000). Current Saskatchewan production is sustained at these levels (Gracie and Tourigny, 2000), employing high proportions of northern and native residents.

Unconformity-type deposits are the highest grade, lowest cost uranium resource in the world. The 1.7-billion-year-old Athabasca Basin of northern Saskatchewan and Alberta (Fig. 1) is the premier host for unconformity-type deposits and has an estimated resource in excess of 375 000 t U (969.6 M lbs U_3O_8). The deposits are located at or below the basal unconformity of the Basin, where kilometre-thick sandstone overlies much older, complex gneissic rocks of the Canadian Shield. Because it takes 10 to 15 years from discovery to mining, exploration companies in this field must plan far in advance and have been consistent supporters of geoscience research. While exploration for new unconformity-type deposits continues in the Athabasca Basin, other such basins are also being explored around the world, such as the Thelon Basin of the Northwest Territories and Nunavut, Canada, the McArthur Basin of northern Australia, and basins of the Aldan and Anabar shields of Russia and the Indian Shield (Thomas et al., 2002).

Public-domain geoscience framework data on the Athabasca Basin and its mineral deposits were previously acquired up to about 1983 — about 20 years ago. Projects then included comparative studies of exploration methods in the Nuclear Energy Agency / International Atomic Energy Agency (NEA/IAEA) Athabasca Test Area and adjacent regions (Cameron, 1983), a study of basement beneath the Athabasca Basin in Alberta (Gilboy, 1983), and a comprehensive study of the Athabasca Group in northern Saskatchewan (Ramaekers, 1990 — based on work of the early 1980s). Much other research has been conducted by industry consultants and university professors supported by the uranium exploration industry (e.g. Kotzer and Kyser, 1995), and by individual government and industry geologists who have published a number of generalized accounts (e.g. Thomas et al., 2000, and references cited in Andrade et al., 2002). However, many of the results have been kept confidential, and stakeholders have requested renewed public-domain studies.

The EXTECH IV Athabasca uranium multidisciplinary study was developed through needs-and-planning meetings that were organized by stakeholders over a two-year period. It was initiated in April 2000 with funding from the Geological Survey of Canada's Project Approval System and Targeted Geoscience Initiative, matched by cash and in-kind resources from NSERC, the governments of Saskatchewan and Alberta, and two major exploration companies (Cameco and COGEMA), with the participation of the universities of Saskatchewan, Alberta, and Regina, and of Laurentian University. It comprises 15 subprojects (5 geophysical, 7 geological, 1 GIS-database, and 1 co-ordination) (Table 1). The setting of the Athabasca Basin is shown in Figure 1;

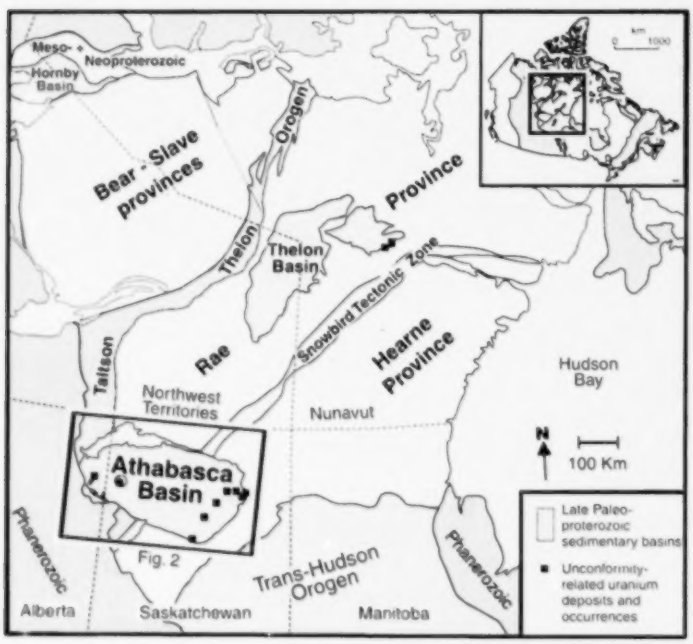

Figure 1.

Location of study area for EXTECH IV, Athabasca uranium multidisciplinary study (http://www.nrcan.gc.ca/gsc/mrd/extech4/index.html). *Northwestern Canadian Shield elements after Thomas et al. (2000), Ruzicka (1996), and Card (2001).*

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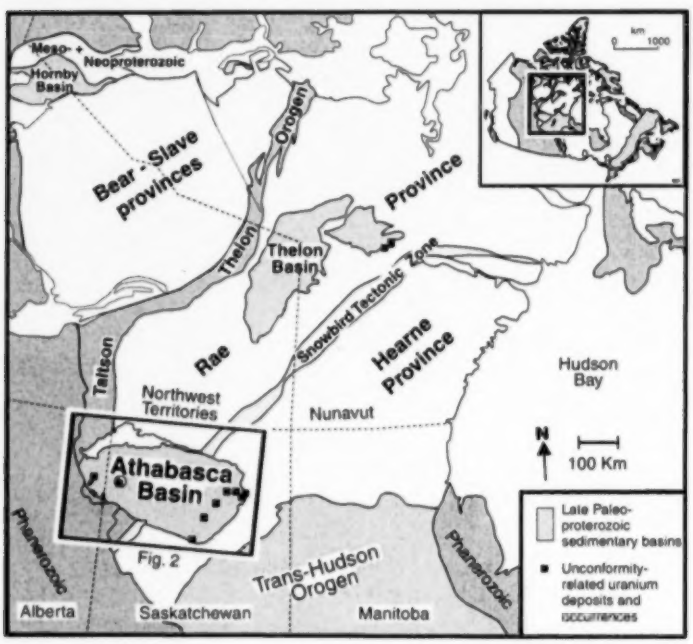

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Table 1. EXTECH IV subprojects. Locations are shown in Figure 2.

1	Regional and high-resolution seismic-reflection surveys
2	Multiparameter borehole geophysics
3	Bitumens, hydrocarbons, fluids, and diagenesis
4	Athabasca stratigraphy and sedimentology
4a	Detailed stratigraphic and sedimentological studies in the Athabasca Basin
5	Basement to western Athabasca Basin
5a	Detailed structural studies of Athabasca uranium deposits
6	Gamma-ray geophysics
6a	Surficial geology
7	Clay mineral studies
8	Co-ordination (Steering Committee)
8a	GIS database and website
9	Electromagnetics and deep graphite exploration
10	High-resolution gravity surveys
11	Geochronology

locations and geological context of the subprojects are shown in Figure 2. Resources totalling $7.5 million have been allocated over three years to acquire and deliver data with preliminary interpretations. A synthesis year is proposed to complete publication of a peer-reviewed comprehensive volume, sponsored by the Saskatchewan Geological Society and the Mineral Deposits Division of the Geological Association of Canada, and to identify future research priorities.

EXTECH IV (EXploration science and TECHnology initiative) aims to enhance the four-dimensional geoscience knowledge base of the 1.7-billion-year-old Athabasca Basin, and to develop new exploration methods for deep uranium deposits that are located at or near its basal unconformity with basement gneisses, thereby sustaining and enhancing the environmentally sound development of this mature mining camp. Each partner has specific goals and is contributing their special expertise, together making EXTECH IV comprehensive. The focus in Saskatchewan is on documenting and archiving existing data on world-class mine areas, and on developing and calibrating new exploration tools. In northeastern Alberta and northern Saskatchewan, new detailed and regional studies are updating and expanding geological information about relatively unexplored portions of the Athabasca Basin to stimulate further mineral exploration (Jefferson and Delaney, 2001).

This paper reviews co-ordination aspects of EXTECH IV (subprojects 8 and 8a) and assesses impacts to date. The EXTECH IV team is listed in Appendix I, along with responsibilities and affiliations. Individual subproject teams, goals, strategies and results for EXTECH IV since September 2001 are summarized in Part 2 and Part 3 of this series (Jefferson et al., 2003a, b). Most results are detailed in Saskatchewan Industry and Resources Summary of Investigation papers delivered on CD-ROM at their early December open house, conveniently providing mid-year information to all clients. A shorter version of these overviews accompanies that volume (Jefferson et al., 2002). Seismic results are also detailed by White et al. (2003).

SUBPROJECT SUMMARIES

Subproject 8: Co-ordination (Steering Committee)

Co-chairs: P. Portella and D. Thomas or J. Marlatt
Co-ordinators: C.W. Jefferson, G. Delaney, and R.A. Olson

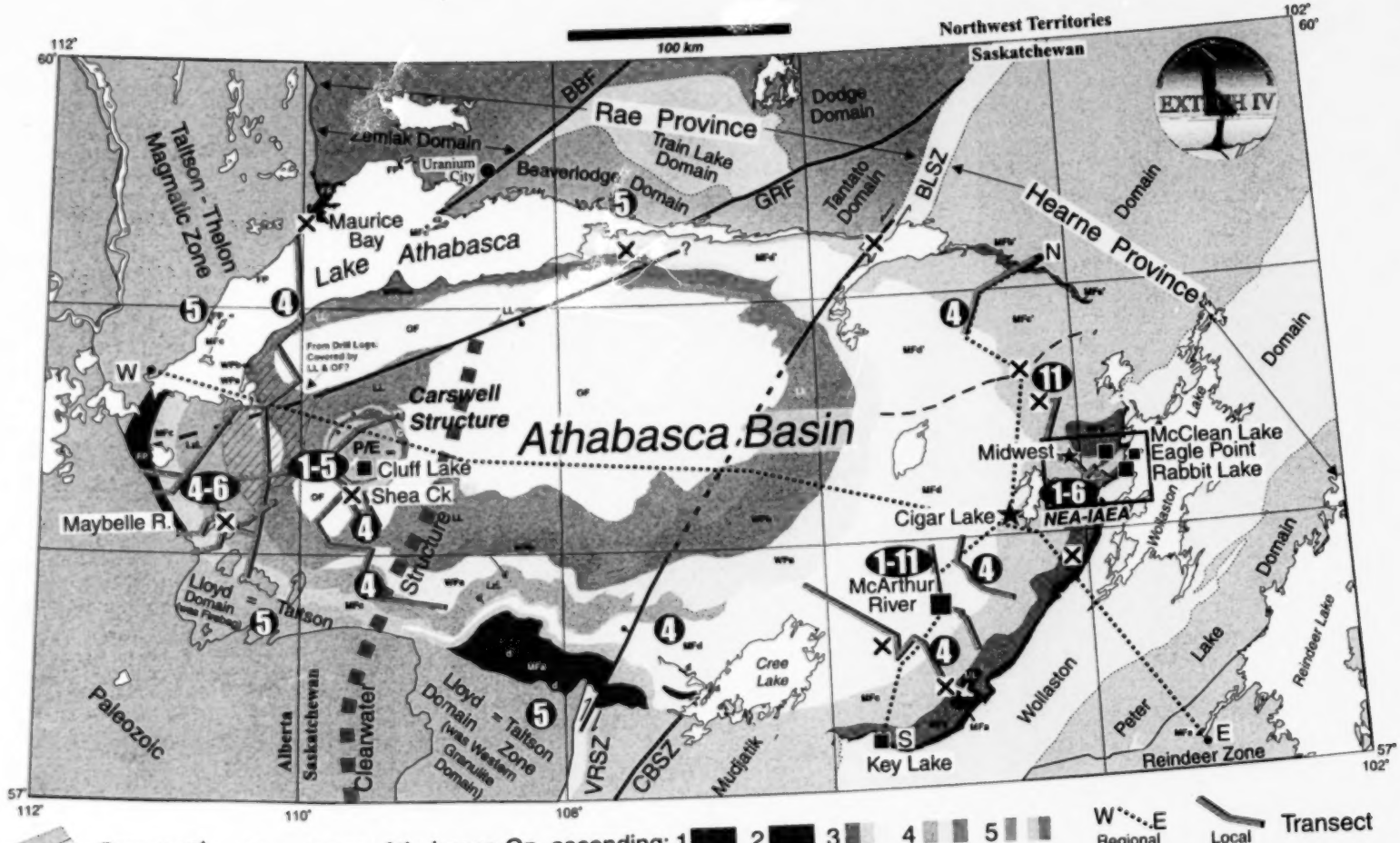
Goals: To ensure co-operation, transparency, integration, timely delivery, and maximum impact of relevant results of EXTECH IV – EXploration science and TECHnology research on Athabasca Basin of northern Saskatchewan and Alberta.

Strategies, plans, and responsibilities: to organize steering committee meetings, timetables and format. To plan the annual technical meetings and workshops, including timetable, format, and participants. To schedule fieldwork and co-ordinate personnel, accommodation and logistics. To prioritize the capital plan (e.g. infrared spectrometer, geophysical equipment, computers). To promote co-ordinated collaborative research, communication, and delivery.

Results for 2002–2003:

1. Co-ordinators ensured full co-operation of staff in all supporting organizations, smoothed logistics for the many activities involved (staff accommodation, transportation, core logging, sampling, mapping, processing of samples, etc.) to enhance efficiency and effectiveness.
2. Communications include newspaper, newsletter and government publications, posters, website, workshop, and Open House plans. Co-ordinators managed and accounted for resource contributions of their respective sponsoring agencies.
3. More than a dozen presentations from EXTECH IV contributed to the Calgary Mineral Exploration Group meeting April 24–25, 2002, and a follow-up workshop that linked eastern and western Athabasca experiences.

Figure 2. Geological sketch map of the Athabasca Basin region (after Ramaekers, 1990; Thomas et al., 2000; Card, 2001; Card and Pana, 2002; and Ramaekers et al., 2001) showing locations of EXTECH IV subproject activity. Note that subproject 10 is included with subprojects 4 and 5. Formations: FP = Fair Point; MFa through MFd = Manitou Falls; LzL = Lazenby Lake; WPa, b = Wolverine Point; LL = Locker Lake; OF = Otherside; WR = undivided William River Subgroup; D = Douglas River; C = Carswell. Other rock units: d = diabase; ML = Moore Lakes gabbro complex; P/E = undivided Peter River / Earl River gneiss units, Carswell Structure. Faults: BBF = Black Bay; GRF = Grease River. Shear zones: BLSZ = Black Lake; CBSZ = Cable Bay; VRSZ = Virgin River. 'NEA-IAEA' box = NEA-IAEA test area.



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4. Each subproject leader updated their synopsis, including work plans and budgets. Initial fieldwork was guided by these, and a logistical framework was developed to facilitate collaboration and optimize logistics.

5. Twenty-six presentations from EXTECH IV at Special Session 18 (Athabasca Basin and its uranium deposits) of the GAC-MAC Annual Meeting, held on May 27–28, 2002, were supplemented by 16 additional presentations from peer academic and exploration researchers, making Special Session 18 the largest at Saskatoon 2002. Wrap-up comments by D. Quirt and P. Ramaekers summarized the main contributions and enhanced their value to stakeholders by showing the relationships between basin evolution and foci of uranium deposition. All EXTECH posters and talks, and some from peers, were compiled on a CD-ROM distributed to partners.

6. Geophysical workshops were held in Saskatoon on June 4, 2002, focusing on Seismic Reflection, and on September 25, 2002, focusing on multiparameter geophysical integration. At each workshop, progress was reported, and issues and actions were determined and subsequently followed up on.

7. A field trip from August 22 to 25, 2002 featured the recently published GAC guidebook (Andrade et al., 2002) and supplementary notes. More than 20 participants represented Cameco, COGEMA, the Cigar Lake Mining Corp., GSC, Saskatchewan Industry and Resources, Saskatchewan Research Council, and the South Australian Office of Minerals and Energy Resources. Participants saw new material at each site, reviewed common approaches to fieldwork, were brought up to date with basement and stratigraphic work of EXTECH IV and Saskatchewan Industry and Resources mapping projects, and held a brainstorming session to review and suggest future priorities for EXTECH IV as well as possible follow-up projects.

8. All EXTECH subprojects will contribute to a workshop planned for December 5–6, 2002. Individual subproject working groups have met or are meeting on separate occasions to allow more in-depth discussion, for example at a general workshop on April 26, 2002 after Calgary's Mineral Exploration Group meeting, at the above-mentioned geophysics workshops and field trip, and at a stratigraphy-sedimentology workshop held on October 30, 2002. Partners are ensuring that key team members attend these workshops for full, informal, around-the-table discussion of results, data gaps, issues, and future directions. Minutes and action items are distributed and implemented.

9. Ongoing results of all subprojects from the Mineral Exploration Group workshop and Geological Association of Canada meeting are captured in EXTECH IV CD-ROMs, as will be public talks and posters at Saskatchewan Industry and Resources' annual Open House, December 3–4, 2002. Final reports due March 31, 2003 will be distributed to partners and undergo peer review for publication in a final volume in 2004.

Subproject 8a: GIS database and website

Co-leaders: W. Slimmon, J. Waters

Team: I. Aldrich, Z. Amer, R. Bennett, G. Delaney, René Droter, C.W. Jefferson, B. Kupsch, S. Russel, R. Moroz, J.C. Mwenifumbo, R.B.K. Shives, K. Tong, G.M. Yeo, and G. Zaluski

Goals: To design and compile a GIS database of all project results — mapping, locations of diamond drillholes, mineral occurrences, assessment work, sections measured, seismic lines, borehole geophysics, gamma-ray geophysics, etc. The database will include all possible public-domain data, and may include some previously acquired industry data locations at the discretion and with consensus of the Steering Committee.

Strategies, plans, and responsibilities: Consistent with the written Letter of Agreement on data ownership issues, compilation and maintenance of database will reside with Saskatchewan Industry and Resources — accessible to all partners. Architecture will be developed through consultation with Subproject team and other subproject leaders, in ArcView® format linked to Microsoft® Access. Subproject teams will identify existing databases and updated data that can be integrated into the GIS. The GIS database will provide data to subprojects to facilitate data integration during further data acquisition and interpretation.

Results for 2002–2003:

1. An extensive GIS database has been built by Saskatchewan Industry and Resources in ArcView® format and is providing data to participating scientists and co-ordinators as needed. A Year 2 report provided to partners on CD-ROM included a complete listing of database contents. These data are being released, as their confidentiality expires, in semiannual CD-ROM compilations of Saskatchewan geological investigations. Data entry and analysis are ongoing. Generalized contents to date include: a) 10 base maps at scales of 1:1 000 000 to 1:50 000; b) 15 geology maps at scales of 1:1 000 000 to 1:20 000; c) 19 working data sets such as drill core collections and locations, geochemistry, geochronology, mines and mineral deposits, paleocurrent data, and references; and d) preliminary data from 14 subprojects, including locations of data collected, drill logs, some geophysical data sets, and a variety of images.

2. Data compiled and generated by the Alberta Geological Survey for EXTECH are hosted by a Microsoft®Access database that was designed to accommodate database needs for other projects at the Alberta Geological Survey, yet at the same time permit effective data exchange with the Saskatchewan-hosted database for drill-core logs, samples, petrology, stratigraphy, geophysics, and EXTECH IV data.

3. A regional basin map updated by Ramaekers, under contract to Alberta Geological Survey and GSC, forms a new base for information exchange and resolves previous inconsistencies at the Alberta–Saskatchewan border (Ramaekers et al., 2001).

4. An updated compendium of drillhole locations within Alberta identifies the Athabasca Basin and underlying Precambrian basement core in storage at the Alberta Geological Survey Mineral Core Research Facility, and tabulates the various publications, including prior industry assessment reports, that contain information pertinent to the Athabasca Basin EXTECH IV project. This builds on Kupsch and Olson (2000), includes 86 new drill logs (41 new this year), and will be reissued as an interactive GIS product (Alberta Geological Survey Earth Sciences Report 2002-01) by March 31, 2003.

IMPACTS TO DATE

Qualitative impacts of EXTECH IV for 2001–2002, addressing the original needs analysis

1. Modern geoscience framework

- A much improved detailed and basin-wide stratigraphic and structural framework has enhanced consistency between exploration projects and confidence in prospectivity models.
- Enhanced participation of exploration staff in subprojects has expanded and/or redirected every EXTECH IV subproject to meet new opportunities.
- Geochronology subproject was created to quantify relative and absolute rates of basin development and mineralization processes.
- Direct industry funding and in-kind support (>$50 000) of detailed follow-up magnetotelluric and gravity transects and of borehole geophysics was incremental to previous levels of support.

2. Capture data for posterity

- Modern databases in Saskatchewan and Alberta have archived important data across the spectrum of uranium exploration needs, from both existing and new sources.
- Lost data have been found and archived (e.g. Ramaekers' original and irreplaceable paleocurrent and other outcrop data).
- Old data have been converted and recompiled to reveal previously unrecognized geochemical trends (NATGAM compilation for northern Saskatchewan and eastern Alberta).

3. Develop and transfer exploration technology (includes training young scientists)

- High participation of industry staff in field projects. As they rotate from one project area to another, they transfer new insights among subprojects with which they are associated.
- Adoption of initial and improved EXTECH IV technologies, practices, and products, such as geophysical stratigraphic and field-logging parameters, structural frameworks, and seismic, magnetotelluric and gravity methods.
- Industry participation in an EXTECH IV workshop held in Saskatoon in November 2001 was unexpectedly high (>80), because Cameco and COGEMA required all staff to attend.
- High participation in EXTECH IV workshops held in Calgary on April 25, 2002 and in Saskatoon on June 4, 2002 and September 25, 2002.
- Special seminars and field trips have reached more industry staff directly on the job (Bitumens, Stratigraphy, Basement geology subprojects).
- National socio-economic impact has been effected by cost-shared training of young, highly qualified persons: a post-doctoral fellow with expertise in seismic reflection, a Ph.D. candidate with expertise in seismic reflection and structural geology, and three M.Sc. and five B.Sc. students specializing in stratigraphy and sedimentology; and by cost-shared staffing of a structural geologist and a specialist in combined ore and organic petrology.
- The Alberta Geological Survey has hired a recent M.Sc. graduate on a six-month term to extend data collection and to acquire training in EXTECH IV technology for the purpose of enhancing Alberta expertise in core-logging techniques, stratigraphy, and sedimentology.

4. Sustainable development and northern employment

- First Nations and other staff of industry partners have expressed interest in further training related to the type of work being done under EXTECH IV.
- Industry partners have expressed satisfaction that the high-quality geoscience information will help them to make wise decisions that will sustain exploration and development, and thereby sustain northern employment.

Quantitative impact analysis

Economic analysis of the impacts of geoscience framework studies normally requires time frames on the order of decades. Although it is premature to evaluate impacts of EXTECH IV in terms of dollars spent (EXTECH II underwent impact analysis after its fourth of five years, whereas EXTECH IV is a three-year project), some early results can be documented, as follows:

- About 395 000 hectares of the Alberta portion of the Athabasca Basin were staked in late 2001–early 2002 by Valley Gold Ltd. and Consolidated Excelerated Resources Ltd., largely as a result of the Alberta Geological Survey communicating EXTECH IV information. (Some staking was for diamonds based on another Alberta Geological Survey data release on kimberlite indicator minerals.) The entire Alberta portion of the Athabasca Basin is now staked.

- A second conductor was indicated in the McArthur River area by the initial magnetotelluric survey, leading to an additional $18 000 in EXTECH funding from partners and to plans for new industry drilling programs to investigate the anomalies. The typical cost of an exploration drillhole in the McArthur River area is $70 000 (drilling costs only, not including geologist time, camp costs, geochemistry, geophysical analysis).
- Current surface-exploration budgets for uranium in northern Saskatchewan were estimated by Gracie and Tourigny (2002) to be in the order of $14 million to $17 million annually. Company representatives on the Steering Committee have expressed appreciation for the high quality of geoscience data from EXTECH IV that they can consider in making strategic exploration and land-management decisions.
- Fifty per cent of the employees in the nuclear energy industry of northern Saskatchewan are northerners, and of those, 80% are aboriginal. It is the main private-sector employer in northern Saskatchewan. All mining companies offer extensive training to their employees, and the average salary (including benefits) of an employee in the mining industry is more than $55 000 per year. The mining industry spends approximately $2 billion annually on wages, goods, and services across Saskatchewan. Uranium mining is a technological leader — 85% of the work force uses advanced technology. EXTECH IV's contributions to the health of this industry thereby assist the social and economic health of northern Saskatchewan and Alberta.
- EXTECH IV total resource contributions have increased from a planned $3.9 million to a projected $7.4 million over the three-year life of the project, concluding in March 2003. This resulted from new contributions by NSERC and Alberta and additional contributions by original partners in recognition of early technical successes. Considering the 20-year gap in public-domain geoscience activity, the data contributed will be strategic and of high quality.

ACKNOWLEDGMENTS

The authors are grateful for the combined energy and enthusiasm of the more than 80 scientists and managers from all partners in this project who have achieved such remarkable results in only 2.5 years. Funding approved by managers of our partner organizations and NSERC has been strong and sustained, and has allowed us to involve and train young scientists who in turn have done some of the best work. In-kind expertise and guidance, combined with logistical and cash support from Cameco and COGEMA from inception to the present, have been outstanding. Critical reviews by Don White, Jeanne Percival, and Jonathan Mwenifumbo, and comments from each subproject team, improved the manuscript.

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Appendix 1

EXTECH IV participants and their roles

Surname	First	Subproject	Title
Co-chairs of Steering Committee			
Thomas	Dave	8	Senior Geoscientist, Cameco
Portella	Philippe	8	District Geologist, East Athabasca, CRI
Project co-ordinators and members of Steering Committee			
Jefferson	Charlie	4, 4a, 8	Research Scientist, MRD, GSC
Delaney	Gary	8	Director, Northern Geological Survey Branch, SIR
Olson	Reg	8	Leader, Minerals Section, AGS
Technical advisors (most active during inception and Year 1)			
Ahuja	Suraj	8	SKAN Consulting Inc.
Annesley	Irvine	8	Senior Research Geologist, Mineral Exploration, SRC
Ansdell	Kevin	8	Associate Professor, U of S
Bethune	Kathryn	8	Assistant Professor, U of R
Brisbin	Dan	8	Senior Economic Geologist
Marlatt	Jim	8	Director, Global Exploration, Cameco
Ranganathan	Ranga	8	Director, Mineral Exploration Branch, SRC
Reeves	Phil	8	Executive Director, SMA
Rippert	Jean-Claude	8	Vice-President of Exploration, CRI
Sopuck	Vlad	8	Chief Geologist, Cameco
Subproject leaders and co-leaders			
Hajnal	Zoltan (zoli)	1	Professor, U of S, Seismic
White	Don	1	Research Scientist, Seismic, CGD, GSC
Mwenifumbo	Jonathan	2	Head, Borehole Geophysics, MRD, GSC
Stasiuk	Lavern	3	Research Scientist, GSC-C
Wilson	Nick	3	Research Scientist, GSC-C
Yeo	Gary	4	Project Geologist, Northern Geological Survey Branch, SIR
Long	Darrel	4a	Professor, Geology Dept., LU
Catuneanu	Octavian	4a	Associate Professor, U of A
Card	Colin	5	Geologist, Northern Geological Survey Branch, SIR
Tourigny	Ghislain	5a	Resident Geologist, La Ronge, SIR
Shives	Rob	6	Radiation Geophysics Section, MRD, GSC
Campbell	Janet	6a	Quaternary Geologist, Northern Geological Survey Branch, SIR
Klassen	Rod	6a	Research Scientist, TSD, GSC
Percival	Jeanne	7	Research Scientist, MRD, GSC
Slimmon	Bill	8a	Geologist, Northern Geological Survey Branch, SIR
Waters	Joan	8a	Computer/GIS Geologist, AGS
Craven	Jim	9	Head, Potential Fields Section, CGD, GSC
Hearty	Bryne	10	Gravity Surveys Database, GC
Thomas	Mike	10	Research Scientist, CGD, GSC
Stern	Richard	11	Research Scientist, CGD, GSC
Subproject co-investigators, listed in alphabetical order			
Ashton	Ken	5	Project Geologist, Northern Geological Survey Branch; Adjunct Professor, U of R
Belyk	Cory	4	Project Geologist, Cameco
Bennett	Rick	8a	Mineral Assessment Files Geologist, SIR
Bernier	Sebastien	4a	M.Sc. student, Laurentian University
Bosman	Sean	4a	B.Sc. student, UWO
Collier	Brent	4a	M.Sc. student, Laurentian University
Cutts	Craig	6,6a,7,11	Project Geologist, COGEMA
Drever	Garth	4	Project Geologist, Cameco
Elliott	Barbara	2	Geophysicist, MRD, GSC
Fenton	Mark	6a	Quaternary geologist, AGS
Fowler	Martin	3	Research Scientist, GSC-C

Appendix 1 (cont.)

Surname	First	Subproject	Title
Gaze	Amanda	4	B.Sc. student, U of S
Gilboy	Chris	5	Acting Director, Petroleum Geology Branch, SIR
Grunsky	Eric	6a	Information Management, MRD, GSC (was AGS)
Gyorfi	István (Steve)	1	Ph.D. student, U of S, c/o Z. Hajnal
Harvey	Sean	5a	Industrial Minerals, Northern Geological Survey Branch, SIR (did Ph.D. on Key Lake, U of R)
Hyatt	Bill	2	Borehole Geophysics, MRD, GSC
Ickert	Ryan	4a	B.Sc. student, U of A, c/o O. Catuneanu
Jiricka	Dan	3,4,6a,11	Senior Project Geologist, Cameco
Koch	Rodney	1,2,6,9,10	Chief Geophysicist, CRI
Koning	Erwin	5,5a	Project Geologist, CRI
Kupsch	Barbara	4	M.Sc. student, U of A, c/o O. Catuneanu
Li	Maowen	3	Research Scientist, GSC-C
Madore	Catherine	11	Petrologist, Mineral Exploration, SRC
McHardy	Scott	1,4a	Project Geologist, Cameco
Morrison	Dwayne	3,4,4a	Project Geologist, CRI
Pandit	Bashkar	1	Research Associate, U of S
Pana	Dinu	5	Mineral Deposits & Structure, AGS
Paulen	Roger C.	6a	Quaternary Geology, AGS
Pflug	Karen	2	Geophysicist, Borehole Geophysics Section, MRD, GSC
Powell	Brian	1,2	Chief Geophysicist, Cameco
Qing	Hairou	3	Dept. of Geology, U of R
Quirt	David	6,7	Senior Research Geologist, Mineral Exploration, SRC
Rainbird	Rob	4,11	Research Scientist, CGD, GSC
Ramaekers	Paul	4, 4a	MF Resources Inc
Reif	Trina	7	(Visiting Scientist, GSC) Minerals and Energy Resources, South Australia
Rice	Randy	4	Sedimentology, AGS
Russell	Sam	4a, 8a	EXTECH IV Webmaster; B.Sc. student, UWO
Salisbury	Matt	2	Geophysicist, GSC-A
Takacs	Erno	1	Geophysicist, PDF, U Sask
Tong	Ken	8a	Graphics and GIS, SIR
Wasyliuk	Ken	6,7	Clay mineralogy, Cameco
Wheatley	Ken	3,4,5,6,7	District Geologist, West Athabasca, CRI
Williamson	Cathy	4a	B.Sc. Student, U of R, c/o H. Qing
Wood	Garnet	6,9,10	Project Geophysicist, Cameco
Zaluski	Gerard	2,8a	GIS expert, Cameco

Abbreviations and addresses
AGS = Alberta Geological Survey, 4th Floor, Twin Atria, 4999-98th Avenue, Edmonton, AB, T6B 2X3
Cameco = Cameco Corporation, 2121 - 11th Street West, Saskatoon, SK, S7M 1J3
CGD = Continental Geoscience, GSC, 601 Booth Street, Ottawa, ON, K1A 0E9
CRI = COGEMA Resources Inc., P.O. Box 9204; 825 - 45th St. W., Suite 817 , Saskatoon, SK, S7K 3X5
GC = Geomatics Canada, 615 Booth St., Ottawa, ON K1A 0E9
GSC = Geological Survey of Canada, 601 Booth Street, Ottawa, ON, K1A 0E8
GSC-A = GSC Atlantic Division, 1 Challenger Dr. (P.O. Box 1006), Rm. H-511 , Dartmouth, NS, B2Y 4A2
GSC-C = GSC Calgary Division, 3303 - 33rd St. North West, Rm. 1103 , Calgary, AB, T2L 2A7
LU = Laurentian University, Geology Dept., Ramsey Lake Rd., Sudbury, ON, P3E 2C6
MRD = Mineral Resources Division, GSC, 601 Booth Street, Ottawa, ON, K1A 0E8
SIR = Saskatchewan Industry & Resources, Northern Geol Survey, 2101 Scarth St., Regina, SK, S4P 3V7
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U of S = University of Saskatchewan, Dept. Geol. Sci., 114 Science Pl., Saskatoon, SK, S7N 5E2
UWO = University of Western Ontario, Geology Dept., London, ON, N6A 5B7